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NATIONAL LAUNCH VEHICLE PROGRAM

NATIONAL AEARONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, DC

1964

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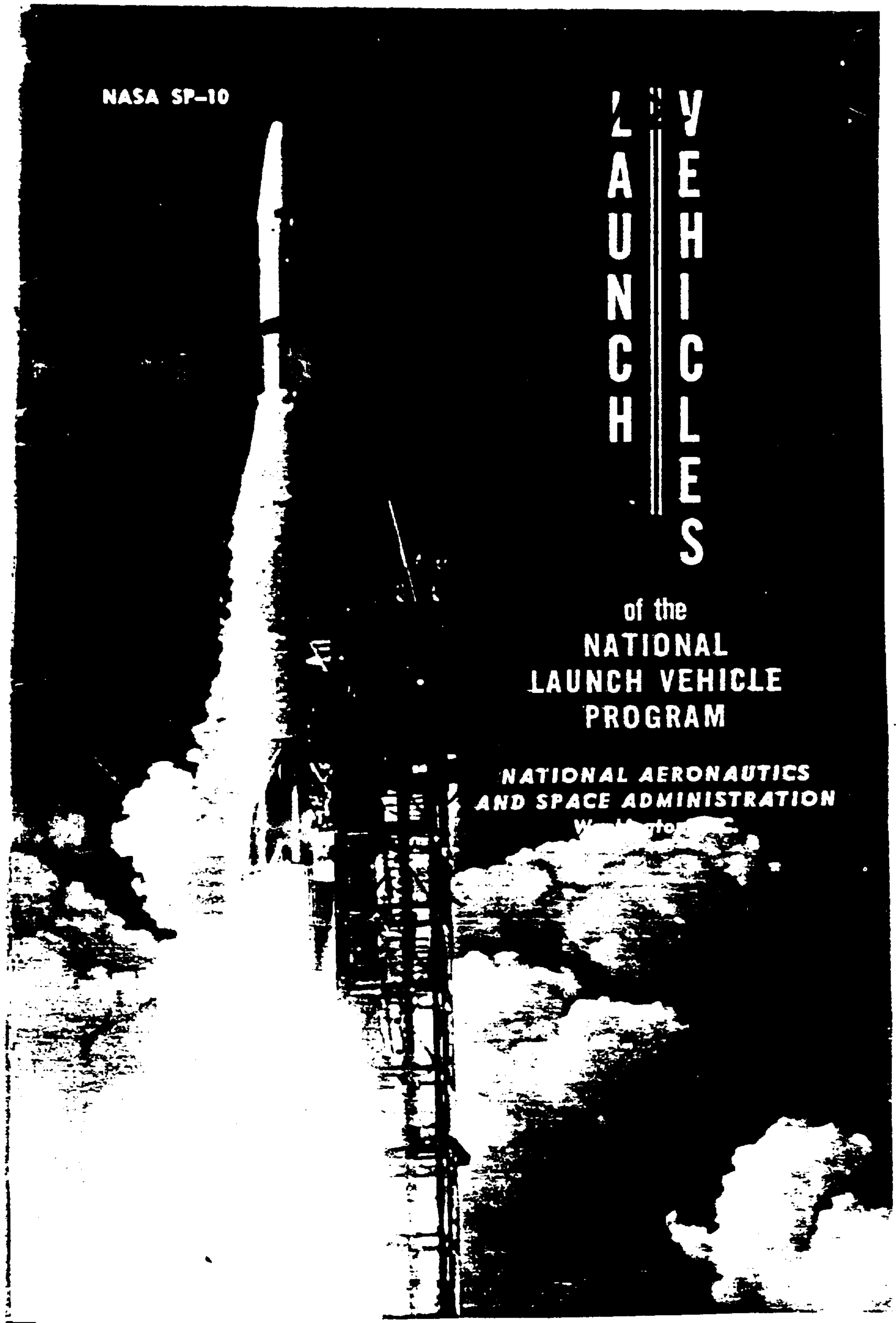

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NASA SP-10
Office of Scientific and Technical Information
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. ● November 1962

Front cover: Atlas–Agena B

INTRODUCTION

THE space research program of the United States, leading in the years just ahead to manned exploration of the moon, and in the more distant future to manned exploration of the near planets, turns on the ability of our scientists and engineers to provide the means for propelling useful payloads through the earth's enveloping atmosphere and into the void of space. For this task, launch vehicles of a number of sizes and capabilities are necessary. Consequently, the United States is developing a family of launch vehicles ranging in size and power from the slender Scout to the giant Nova.

Obviously, it would be unwise to use a ten-ton truck to carry a few parcels or to risk a break-down by overloading a small truck. Similarly, it would be impracticable to use Saturn or Nova to orbit a small, lightweight group of scientific instruments, or take the risk of failure involved in placing too much weight on any size rocket. Either would be expensive and inefficient. By developing a family of reliable launch vehicles, the Nation will have available the right size for the right job and avoid the expense of employing vehicles that are either larger and more powerful than necessary, or are marginal in power for the job at hand.

For each of the nation's launch vehicles, missions have been assigned. These missions range from scientific research and exploration to tasks vitally necessary for the national defense.

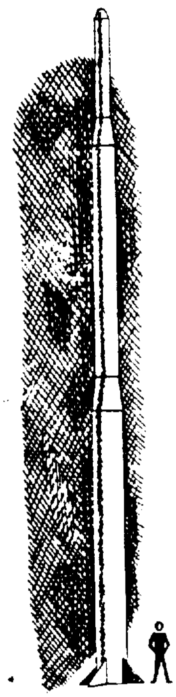
At present, the National Launch Vehicle Program includes twelve basic vehicles. They are Scout, Delta, Thor–Agena B, Thor–Ablestar, Atlas D, Atlas–Agena B, Titan II, Titan III, Centaur, Saturn, Advanced Saturn, and Nova. All of these vehicles, with the exception of the Thor–Ablestar, are described in this booklet.

Responsibilities in the launch vehicle program have been divided between the National Aeronautics and Space Administration and the Department of Defense. Development of six of the twelve vehicles is managed by NASA. These are Scout, Delta, Centaur, Saturn, Advanced Saturn, and Nova. Development of the other six is managed by the Air Force as agent for the Department of Defense. All of them, however, are available to any agency of the Government having work to do in space.

James E. Webb

JAMES E. WEBB

Administrator, National Aeronautics and Space Administration



SCOUT

STAGES: 4

PROPELLANTS: Solid

THRUST: 1st stage (Algol II–A), 86,000 lbs. at sea level; 2nd stage (Castor), 64,000 lbs.; 3rd stage (Antares), 23,000 lbs.; 4th stage (Altair), 3,000 lbs.

MAXIMUM DIAMETER: 3.3 ft., excluding fins

HEIGHT: 65 ft., less spacecraft

PAYLOAD: 220 lbs. in 300 n.m. orbit

FIRST NASA LAUNCH: July 1, 1960

USE: Launching of probes and satellites

SCOUT, the smallest member of the basic NASA launch vehicle family, was designed to provide a reliable, relatively inexpensive launch vehicle for many of the smaller payloads needed to conduct space research. It is the only vehicle of the group using solid propellants exclusively.

During its developmental phase, the vehicle launched space probes and orbited a small satellite. Scout is capable of lifting a 400-pound probe into the lower levels of space or placing a 220-pound satellite in a 300-mile orbit. It has the versatility to perform a number of different research missions, including orbital missions, high-altitude probes, and reentry investigations. Some typical Scout missions are shown below.

SCOUT MISSIONS		
Scientific Satellites		
Explorer IX		1961
Explorer XIII		1961
Micrometeorite	4	1961–63
Ionosphere	4	1961–64
Materials	2	1962–64
Probes		
Reentry Heating	6	1962–64
Electric Engines	4	1962–64
Life Science	2	1963–64
International Satellite		
U.K. No. 2		1963

Although the development phase of the Scout launch vehicle has essentially been completed, a program is underway to increase the payload capability from 220 to 300 pounds in the 300-mile orbit. Improvements in some of the engines and the use of the new, high-energy solid propellants which proved successful in the Air Force's Minuteman ICBM and the Navy's Polaris IRBM are expected to bring Scout performance up to the desired level late in 1962 or early in 1963.

NASA's basic Scout program included eight vehicles, with thirty additional Scouts being produced. Approximately 80 percent of the latter will be used for orbital flights. The Department of Defense also makes extensive use of modified versions of the Scout for research. In addition to NASA missions, Scout will be used to launch a number of Air Force experiments, as well as

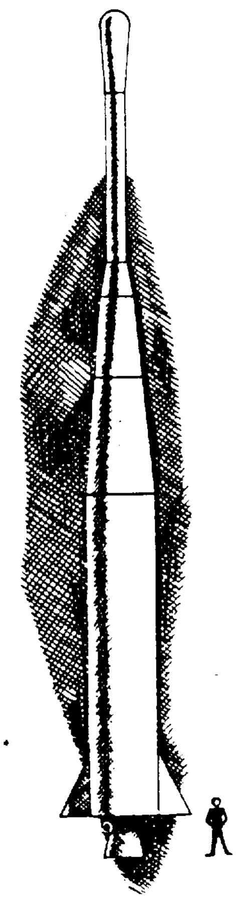
(c)

the navigation and solar radiation satellites for programs sponsored by the Navy.

While the Scout developmental launches were not always successful in all details, in seven out of nine firings the vehicle system performed properly. Ignition failures and a tipoff* problem were the chief difficulties encountered. One of the major development items, the guidance and control system, operated perfectly on all nine flights. In addition, the Scout vehicle launched five useful experiments during the development period. Some vehicles under development carry vehicle instrumentation only. The initial Scout program carried out not only the satisfactory development of the first all-solid-propelled space vehicle, but also performed the following experiments:

Experiment	*Date*
Air Force payload	October 1960
Explorer IX	February 1961
Air density experiment using a 12-ft.-diameter balloon	
P–21	October 1961
Electron density profile probe of the ionosphere	
High-speed reentry heating test	March 1962
P–21a	
Ionosphere probe	March 1962

*A disturbance during the separation of the third stage causing the fourth stage to veer off its planned trajectory. The problem has been solved in the Scout program.



DELTA

STAGES: 3

PROPELLANTS: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd stage, unsymmetrical dimethylhydrazine (UDMH) and inhibited red fuming nitric acid (IRFNA); 3rd stage, solid

THRUST: 1st stage (Thor, DM-21), 170.000 lbs. at sea level; 2nd stage (AJ10-118), 7.700 lbs.; 3rd stage (Altair), 2,800 lbs.

MAXIMUM DIAMETER: 8 ft., excluding fins

HEIGHT: 88 ft., less spacecraft

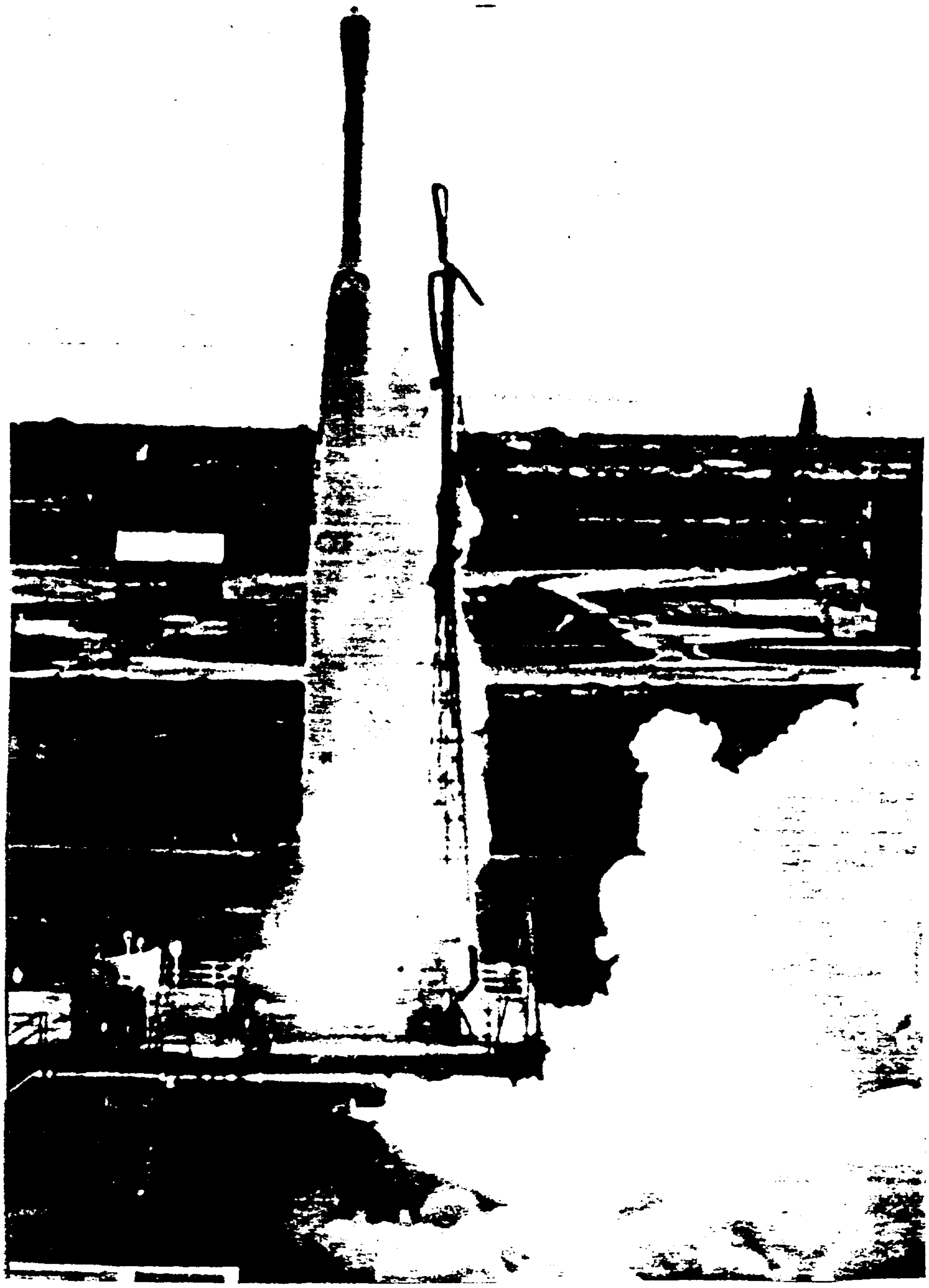
PAYLOAD: 800 lbs. in 350 n.m. orbit; 130 lbs. escape

FIRST NASA LAUNCH: May 13, 1960

USE: Launching of scientific satellites and space probes

THE Delta launch vehicle was originally intended as an interim vehicle for medium payload satellites and small space probes until newer vehicles such as Scout and Thor–Agena B became fully operational. Delta has proved, however, to be one of the most reliable launch vehicles the United States possesses, with a long list of successful firings to its credit.

The 90-foot vehicle uses a modified Thor as its first stage, a modified and improved second stage from the Vanguard and



Thor–Able programs, and the spin-stabilized, solid-propellant Altair for its third stage. The Altair also derived from the earlier Vanguard and Thor–Able vehicles. Delta thus utilizes proven engines, modified to achieve higher reliability and to perform newer missions.

With about three times the payload capability of Scout, the Delta is also used for launching a wide variety of satellites and probes. The first launching, an attempt in May of 1960 to orbit the first Echo satellite, failed due to an upper-stage malfunction. Delta launches to date are listed in the following table:

DELTA LAUNCHINGS

Date	*Payload*	*Date*	*Payload*
May 1960	Echo	March 1962	OSO
August 1960	Echo I	April 1962	Ariel
November 1960	Tiros II	June 1962	Tiros V
March 1961	Explorer X	July 1962	Telstar
July 1961	Tiros III	September 1962	Tiros VI
August 1961	Explorer XII	October 1962	Explorer XIV
February 1962	Tiros IV	October 1962	Explorer XV

Echo I is the passive communications satellite which is still visible to the unaided eye. The Tiros meteorological satellites transmit invaluable photographic weather data. Explorer X is a scientific spacecraft for measuring magnetic and plasma fields in interplanetary space. It was placed in a difficult, highly eccentric orbit by Delta, as was Explorer XII, a satellite for measuring energetic particles and fields. Delta lofted OSO, the Orbiting Solar Observatory, into an orbit of 340 statute miles perigee and 370 statute miles apogee. Ariel is the international

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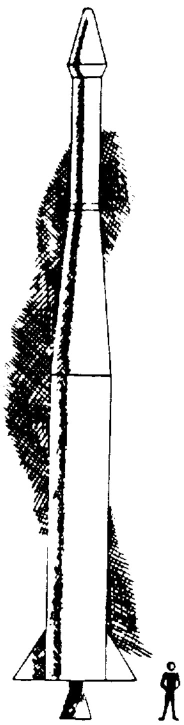
ionospheric investigation satellite—a cooperative project between the United States and the United Kingdom. It is sometimes referred to as U.K. No. 1. Telstar is a private communications satellite launched by NASA for the American Telephone and Telegraph Company. Explorer XV marked the thirteenth straight successful Delta launching.

The original Delta program included only 12 vehicles, but the relatively low cost and high reliability have resulted in additional payload assignments and the procurement of 14 additional vehicles. Delta is scheduled to launch later Tiros satellites as well as NASA's first two active communications satellites, Relay and Syncom.

DELTA MISSIONS

Communications		
Echo I		1960
Telstar (AT&T)	4	1962
Relay	3	1962–63
Syncom	3	1962–63
Meteorology		
Tiros	7	1960–63
Scientific Satellites		
Explorer X		1961
Explorer XII		1961
Orbiting Solar Observatory		1962
Atmospheric Structure		1962–63
International Satellite		
Ariel (U.K. No. 1)		1962



THOR–AGENA B

STAGES: 2

PROPELLANTS: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd stage, unsymmetrical dimethylhydrazine (UDMH) and inhibited red fuming nitric acid (IRFNA)

THRUST: 1st stage (Thor, DM–21), 170,000 lbs. at sea level; 2nd stage (Agena B), 16,000 lbs.

MAXIMUM DIAMETER: 8 ft., excluding fins

HEIGHT: 76 ft., less spacecraft

PAYLOAD: 1,600 lbs. in 300 n.m. orbit

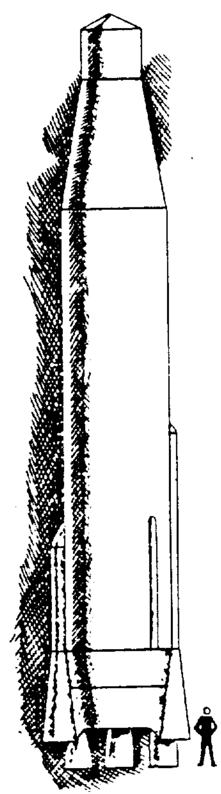
FIRST NASA LAUNCH: 1962

USE: Launching of meteorological, communications, and scientific satellites

THE Thor–Agena B employs the restartable Agena second stage that permits great precision in selecting an orbit. The Agena was developed by the Air Force as a second stage for use in its own programs. Early in 1960 the National Aeronautics and Space Administration decided to use the Agena in combination with the Thor and the Atlas rather than develop a similar vehicle. The NASA version of the Agena B is modified slightly so that various types of payloads can be bolted onto the front-end. The Air Force has under development a standard vehicle called the Agena D, which will also be made available to NASA in 1963 or 1964.

The Thor–Agena B combination can place 1,600 pounds in a 300-nautical-mile orbit. It is being used by NASA for the launching of meteorological, communications, and scientific satellites. Thor–Agena B missions are listed below:

Scientific		
Topside Ionospheric Sounder	1	1962
Polar Orbiting Geophysical Observatory	1	1964
Meteorological		
Nimbus Satellites	7	1963–64
Communications		
Echo (Rigidized Sphere)	1	1962



ATLAS D

STAGES: 1½

PROPELLANT: Liquid oxygen and kerosene (LOX/RP)

THRUST: 367,000 lbs. at sea level

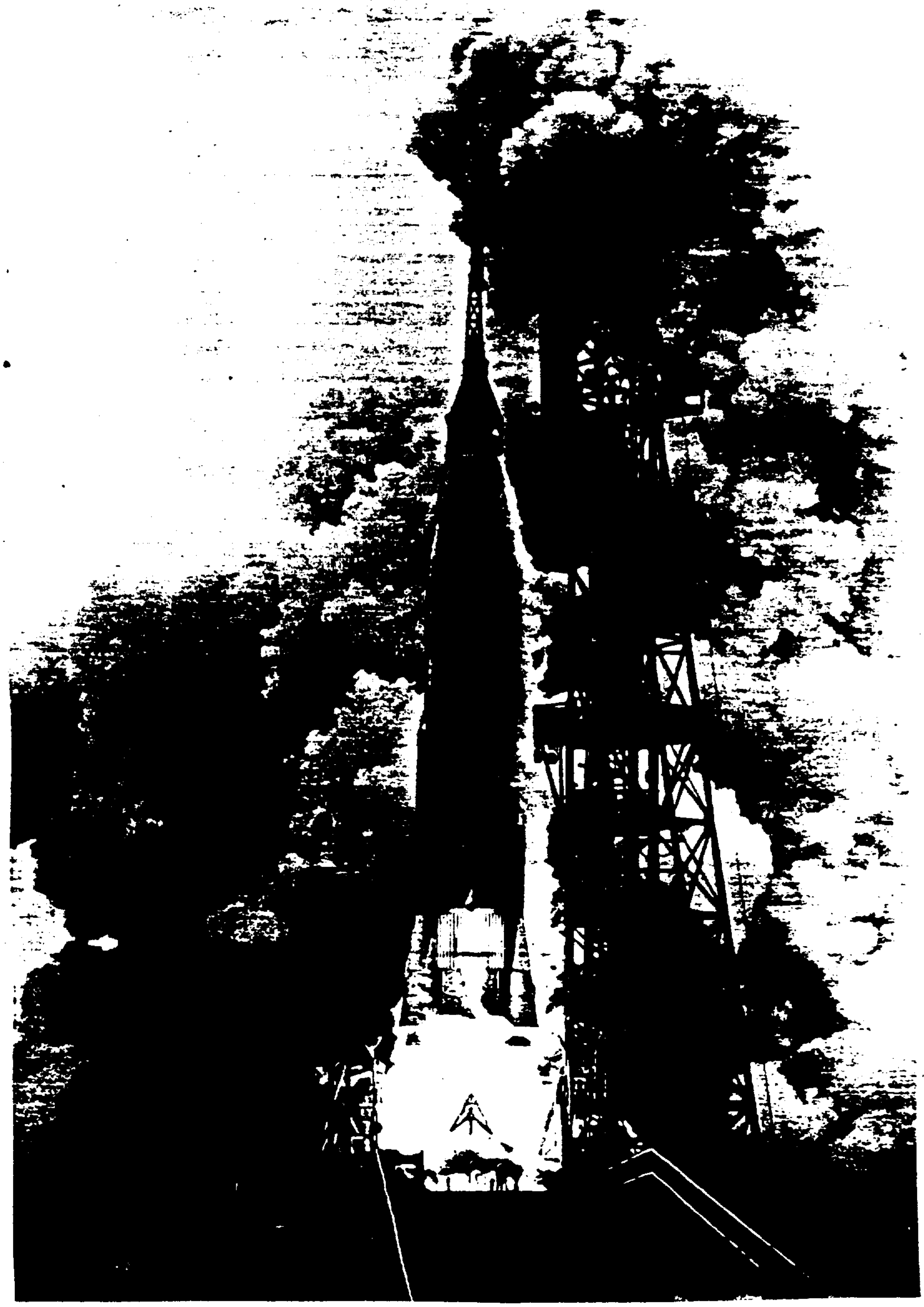
MAXIMUM DIAMETER: 10 ft. (16 ft. at base)

HEIGHT: 72 ft., less spacecraft

PAYLOAD: 2,700 lbs. in 100 n.m. orbit

FIRST NASA LAUNCH: July 29, 1960

USE: Launching of the manned Mercury capsule



FIFTH among the launch vehicles employed in the National Launch Vehicle Program is the Atlas D, a modified Air Force intercontinental ballistic missile. The Atlas D is a one-and-one-half-stage vehicle propelled by three engines. The thrust of these engines is sufficient, however, to place the Mercury capsule and the empty Atlas D into an orbit of approximately 100 miles.

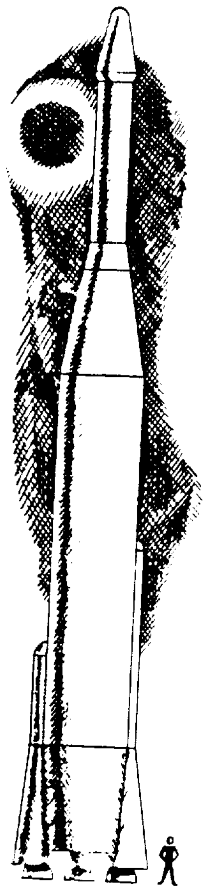
All three engines are ignited at launch. The outer two, counted as a half stage, are jettisoned at the end of their burning period. The sustainer engine continues to burn until orbital velocity is obtained.

The Atlas is constructed of thin-gage stainless steel, and its structural rigidity is maintained through internal pressurization. Heavier gage skin is required at the forward end of the liquid-oxygen tank to provide for increased aerodynamic stresses imposed by the payload. Also, for the Mercury mission the payload adapter section is modified and an abort-sensing and implementation system is incorporated. If it senses any malfunction in the performance of the Atlas, it triggers the Mercury's emergency escape system, and the capsule is pushed free of the launch vehicle. In the Mercury application the Atlas is 67.34 feet long from its engines to the capsule adapter section. With the Mercury and its escape tower installed, the carrier is 95.25 feet in length.

The Atlas will no longer be needed as a space booster for NASA after the Mercury spacecraft is phased out.

MANNED MERCURY-ATLAS FLIGHTS

		Astronaut
February 20, 1962	3 orbits	John H. Glenn, Jr.
May 24, 1962	3 orbits	Malcolm Scott Carpenter
October 3, 1962	6 orbits	Walter M. Schirra



ATLAS-AGENA B

STAGES: 2

PROPELLANTS: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd stage, unsymmetrical dimethylhydrazine (UDMH) and inhibited red fuming nitric acid (IRFNA)

THRUST: Atlas D, 367,000 lbs. at sea level; Atlas D sustainer, 80,000 lbs.; Agena B, 16,000 lbs.

MAXIMUM DIAMETER: 10 ft. (16 ft. at base)

HEIGHT: 91 ft., less spacecraft

PAYLOAD: 6,000 lbs. in 300 n.m. orbit; 750 lbs. escape; 425 lbs. to Mars or Venus

FIRST NASA LAUNCH: August 23, 1961

USE: Lunar missions and launching of communications and scientific satellites.

In combination with the Atlas D, the Agena is employed extensively by the Air Force as well as by NASA. As mentioned previously, an Agena D second stage is being developed. The Atlas–Agena is used by NASA for lunar and planetary missions and for launching a variety of communications and scientific satellites. The Atlas–Agena B launched five Ranger spacecraft during 1961 and 1962 in attempts to investigate deep space and the surface of the moon. On the first three attempts the launch vehicle failed to place the spacecraft in its final prescribed trajectory. On the fourth and fifth flights the vehicle performed satisfactorily but the spacecraft malfunctioned. Of two Mariner missions in July and August, 1962, the first attempt failed due to a vehicle malfunction, but the second attempt placed the spacecraft in its proper trajectory.

On the whole, both the Thor–Agena and the Atlas–Agena combinations have proved very reliable, with a long list of successful missions to their credit. They are expected to be workhorses of the National Launch Vehicle Program for a number of years. Until Centaur and Saturn become operational, the Atlas–Agena will perform NASA's heavy duty missions. The NASA missions scheduled for this vehicle are listed below:

Scientific		
Eccentric Geophysical Observatory	2	1963
Orbiting Astronomical Observatory	2	1963–64
Communications		
Advanced Passive Satellite	2	1963–64
Lunar and Planetary		
Ranger (Lunar Reconnaissance)	9	1961–63
Mariner R (Venus Fly-by)	2	1962
Mariner R (Mars Fly-by)	2	1964

The manner in which the Agena vehicle operates may be seen from the description of a Ranger flight.

The single-chamber rocket engine is capable, as mentioned, of being shut off and restarted in space. This operation occurs after the main booster has separated from the Agena and its payload. In effect, the Atlas boosts the Agena and its payload through the earth's atmosphere; the Agena provides the additional thrust to complete the mission.

During a lunar investigation mission such as planned for the Ranger project, the outer engines of the Atlas D burn for about 2½ minutes before cutting off and dropping away. The sustainer engine continues to burn for an additional two minutes, by which time the vehicle has reached 80 miles altitude. Two vernier* engines of 1,000 pounds thrust each burn from launch for approximately five minutes in order to trim velocity after booster cutoff. They are shut off by guidance commands, and an on-board computer commands the Atlas airborne guidance system to start the timer on the Agena stage.

After the verniers are cut off the Atlas–Agena coasts for about 30 seconds. Then the spring-loaded aerodynamic shroud protecting the Ranger payload is discarded. Explosive charges separate the Agena from the Atlas first stage, and retrorockets on the latter slow it down so that it does not interfere with the second stage. The Agena goes through a pitch maneuver to bring it in horizontal alignment with the earth's surface. When this is accomplished, the timer sends a signal to the propulsion system and ignition occurs.

This period of powered flight lasts an additional 2½ minutes, during which time the Agena stage is controlled by the hydraulic control system, with corrections being supplied by an infrared horizon-sensing device. When the Agena engine cuts off, the Ranger payload is in a circular parking orbit approximately 100 miles above the earth. After a 14-minute coasting period, the Agena engine relights and powers the payload for another 1½ minutes, placing it in the lunar trajectory. About 2½ minutes later the Agena and the payload are separated and the Ranger continues alone toward the moon.

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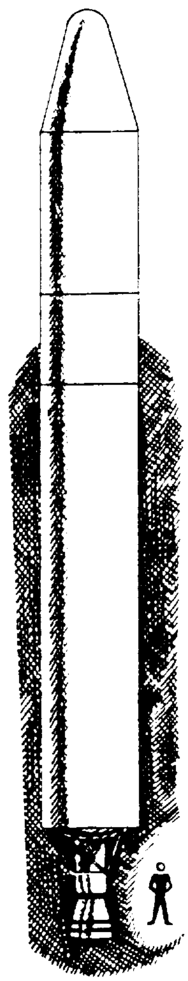
*Verniers are small rocket engines used primarily to obtain a fine adjustment in the velocity and trajectory of a space vehicle or missile.



TITAN II

STAGES: 2

PROPELLANT: Storable (a blend of unsymmetrical dimethylhydrazine (UDMH) and hydrazine as fuel; nitrogen tetroxide as oxidizer)

THRUST: 1st stage (XLR–87), 430,000 lbs. at sea level; 2nd stage (XLR–91), 100,000 lbs.

MAXIMUM DIAMETER: 10 ft.

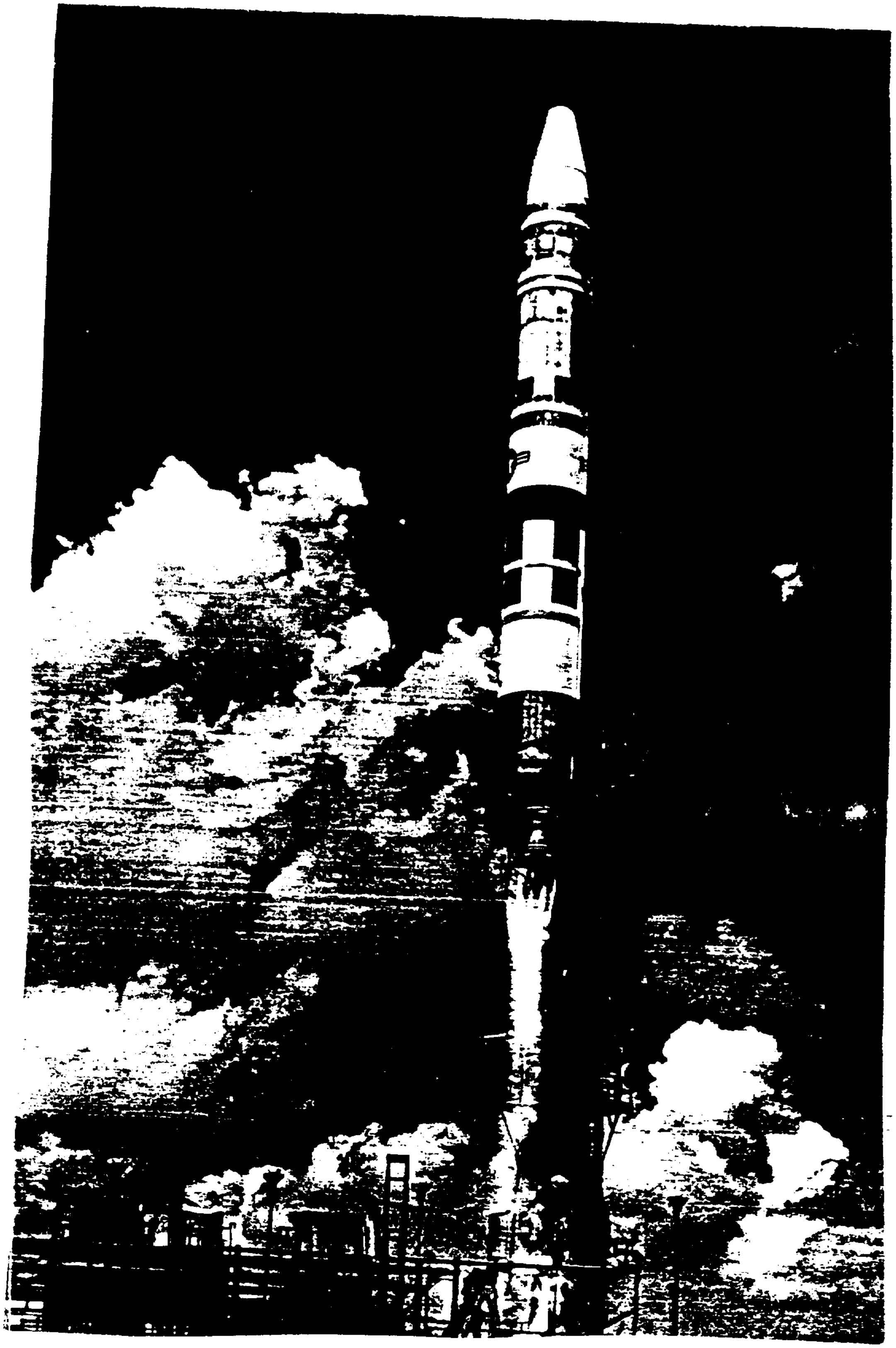
HEIGHT: 90 ft., less spacecraft

PAYLOAD: More than 6,000 lbs. in low earth orbit

FIRST NASA LAUNCH: 1963–64

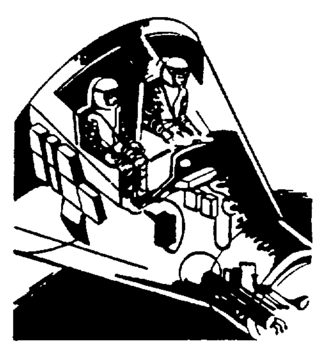
USE: Launching of the two-man Gemini spacecraft

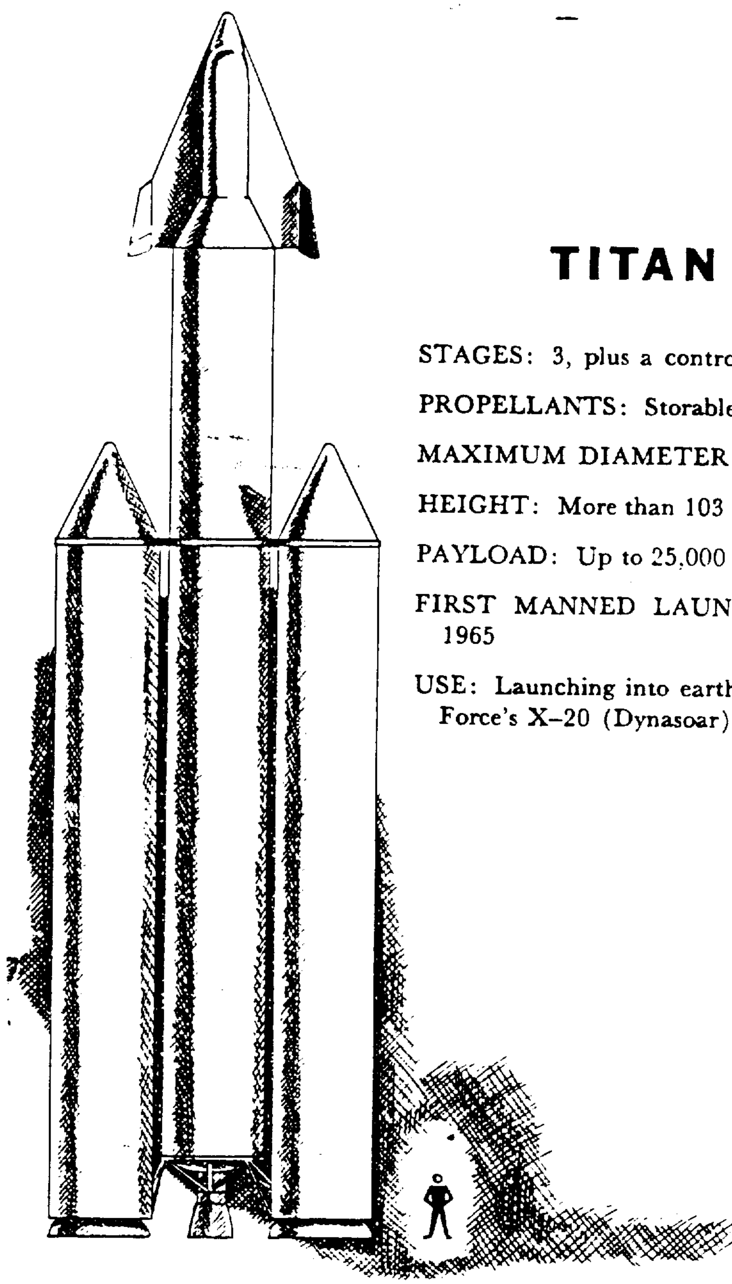
THE Titan II, like the Atlas D, is an Air Force intercontinental ballistic missile which will be adapted by NASA for a specific mission. This carrier has been selected to boost into orbit the Gemini two-man spacecraft. The Titan II has not yet been used as a space carrier vehicle, although it has been flown successfully and its development is well under way.



In its standard military version, the Titan II is 103 feet in length and 10 feet in diameter. It consists of two tandem-mounted stages, the first powered by two 215,000-pound-thrust rocket engines and the second by a single 100,000-pound-thrust rocket engine. All engines operate on a storable hypergolic mixture of nitrogen tetroxide and a combination of unsymmetrical dimethylhydrazine and hydrazine.

Since the Titan II's propellants are storable and ignite on contact, the missile can be readied for military use on short notice. This feature is expected to facilitate NASA launches also. When the Titan II becomes operational and the Gemini development is completed, United States astronauts will be able to practice rendezvous maneuvers in orbit to help pave the way toward successful completion of the later Apollo program.





TITAN III

STAGES: 3, plus a control module

PROPELLANTS: Storable liquid and solid

MAXIMUM DIAMETER: 30 ft.

HEIGHT: More than 103 ft., less spacecraft

PAYLOAD: Up to 25,000 lbs. in earth orbit

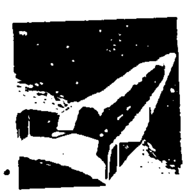
FIRST MANNED LAUNCH BY USAF: 1965

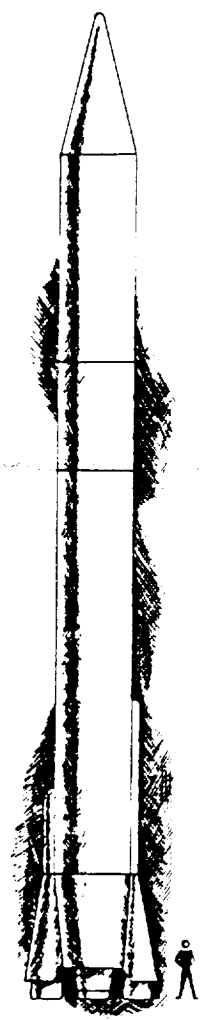
USE: Launching into earth orbit of the Air Force's X-20 (Dynasoar) spacecraft

TITAN III is the first launch vehicle to be developed by the Department of Defense from the outset as a space booster. All current military space boosters are intermediate range or intercontinental range ballistic missiles with minimum modifications combined with upper stages developed separately. Titan III is included in the National Launch Vehicle Program.

Using the "building block" approach, the Titan III vehicle will consist of five basic parts: the storable liquid propellant stages (XLR–87 and XLR–91) of the Titan II, a new storable liquid propellant upper stage producing 16,000 pounds of thrust; a control module, and a pair of 120-inch-diameter segmented strap-on solid propellant motors.

Depending upon the job to be performed, Titan III may be used in either of two standard configurations: (1) the core configuration consisting of a modified Titan II with the new upper stage and control module mounted on top, which has a lift-off thrust of 430,000 pounds; or (2) the Titan II core with two five-segment strap-on solid motors attached, comprising the first boosting stage with a lift-off thrust of over two million pounds (each solid motor develops over one million pounds). In addition the Titan III program calls for the development of a powerful new solid-propellant, first-stage booster.





CENTAUR

STAGES: 2

PROPELLANT: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd stage, liquid oxygen and liquid hydrogen (LOX/LH)

THRUST: Atlas D, 367,000 lbs, at sea level; Atlas D sustainer, 80,000 lbs.; Centaur, 30,000 lbs.

MAXIMUM DIAMETER: 10 ft., excluding fins

HEIGHT: 100 ft., less spacecraft

PAYLOAD: 8,500 lbs. in 300 n.m. orbit; 2,300 lbs. escape; 1,300 lbs. to Mars or Venus

FIRST NASA LAUNCH: May 1962

USE: Launching of earth satellites and lunar and planetary exploration missions.

THE Centaur is expected to be a high-performance, general-purpose launch vehicle for use by the National Aeronautics and Space Administration and the Department of Defense. It requires a pioneer research effort to develop a rocket vehicle to utilize high-energy liquid hydrogen as fuel. Centaur represents such an effort and, as such, will provide much of the basic knowledge required for the design of the upper stages of the Saturn and Nova rocket vehicles, and for the design of the Rover nuclear-propulsion system, all of which will use the same fuel. In addition, Centaur vehicles can carry ion and arc jet electrical propulsion systems for flight tests, and the Mariner B probes intended for the Nation's exploration of the planets Venus and Mars. Centaur will also perform a vital function as a vehicle for preliminary unmanned exploration of the moon's surface (Project Surveyor), and for biomedical flights to help predict the effects on man of various types of radiation encountered in space.

The Centaur can carry 8,500 pounds into low earth orbit or about a ton on a flight to the moon. Essentially, the Centaur consists of an Atlas first stage redesigned to carry a radically different kind of upper stage producing almost twice the thrust of the Agena B. The Centaur second stage has two engines, each producing 15,000 pounds of thrust. The liquid hydrogen used as a propellant is a rocket fuel with great promise but which demands major research and development achievements. The temperature of liquid hydrogen is minus 423° Fahrenheit, just 36° above absolute zero. It is so cold that it must be carefully insulated from the liquid oxygen used as oxidizer—which itself has a temperature of 297° below zero.

Although the first developmental vehicle launch was unsuccessful, the vehicle development flight program is scheduled for completion by the last half of 1964, whereupon Centaur will begin extensive service as an operational space mission launch vehicle.

CENTAUR MISSIONS
Unmanned Soft Lunar Landings   Precise Lunar Orbiters
Observation of Venus and Mars

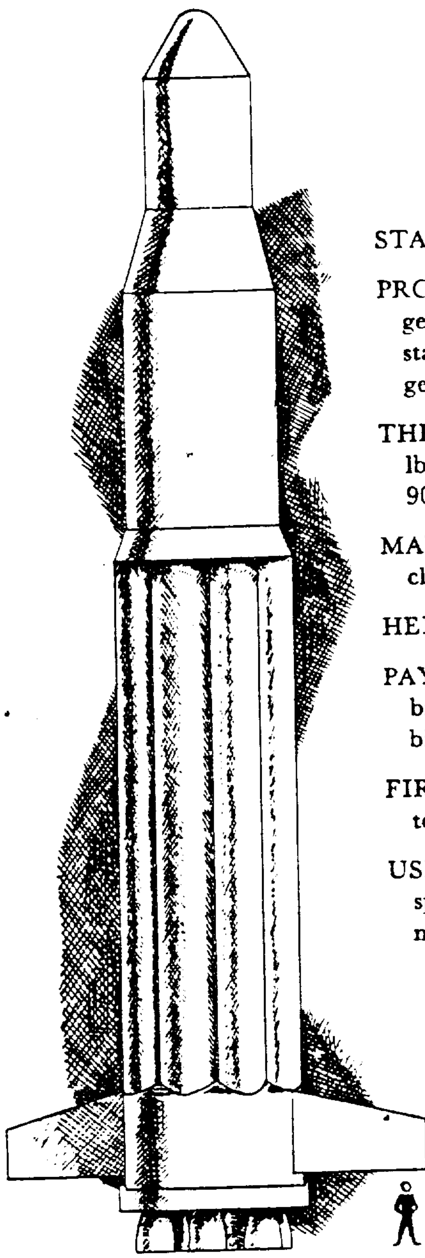
SATURN

THE Saturn launch vehicle now consists of two separate configurations utilizing identical first stages. These configurations are the C–1 and the C–1B. The C–1 was conceived in 1958 to provide an early capability for large payloads. Existing components were utilized wherever possible. The decision to arrange the engines and tanks in clusters permitted the use of equipment developed for the Nation's ballistic missile programs. Thus the first stage of the Saturn C–1 has a cluster of eight H–1 engines, each capable of generating 188,000 pounds of thrust. The second stage employs six liquid-oxygen, liquid-hydrogen RL10–A–3 engines, each generating 15,000 pounds of thrust. The A–3 is the same engine used in the upper stage of the Centaur.

A ten-vehicle, flight development program, comprising four live first-stage flights and six live first- and second-stage flights, is currently underway. The Saturn C–1 has had two successful launches. The first launching of the booster, with inert upper stages, occurred at Cape Canaveral in October 1961. During this 8-minute flight, the rocket reached a peak velocity of 3,600 miles per hour and an altitude of 85 miles before impacting in the Atlantic about 215 miles downrange. Another fully successful launching took place on April 25, 1962. The eight engines generated 1.3 million pounds of thrust. The dummy upper stages were filled with water as ballast, to simulate the weight of a complete vehicle.

A bonus scientific experiment ("Project Highwater") was performed during the second launch. The 95 tons of water carried as ballast was deliberately released by explosion at 65 miles altitude to determine the effects in the cold vacuum of space. This experiment may be repeated in the third launching.

The Saturn C–1 will be used for orbital launchings of developmental models of manned lunar landing craft.



(C–I CONFIGURATION)

STAGES: 2

PROPELLANTS: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd stage, liquid oxygen and liquid hydrogen (LOX/LH)

THRUST: 1st stage (S–I), 1,500,000 lbs. at sea level; 2nd stage (S–IV), 90,000 lbs. in a vacuum

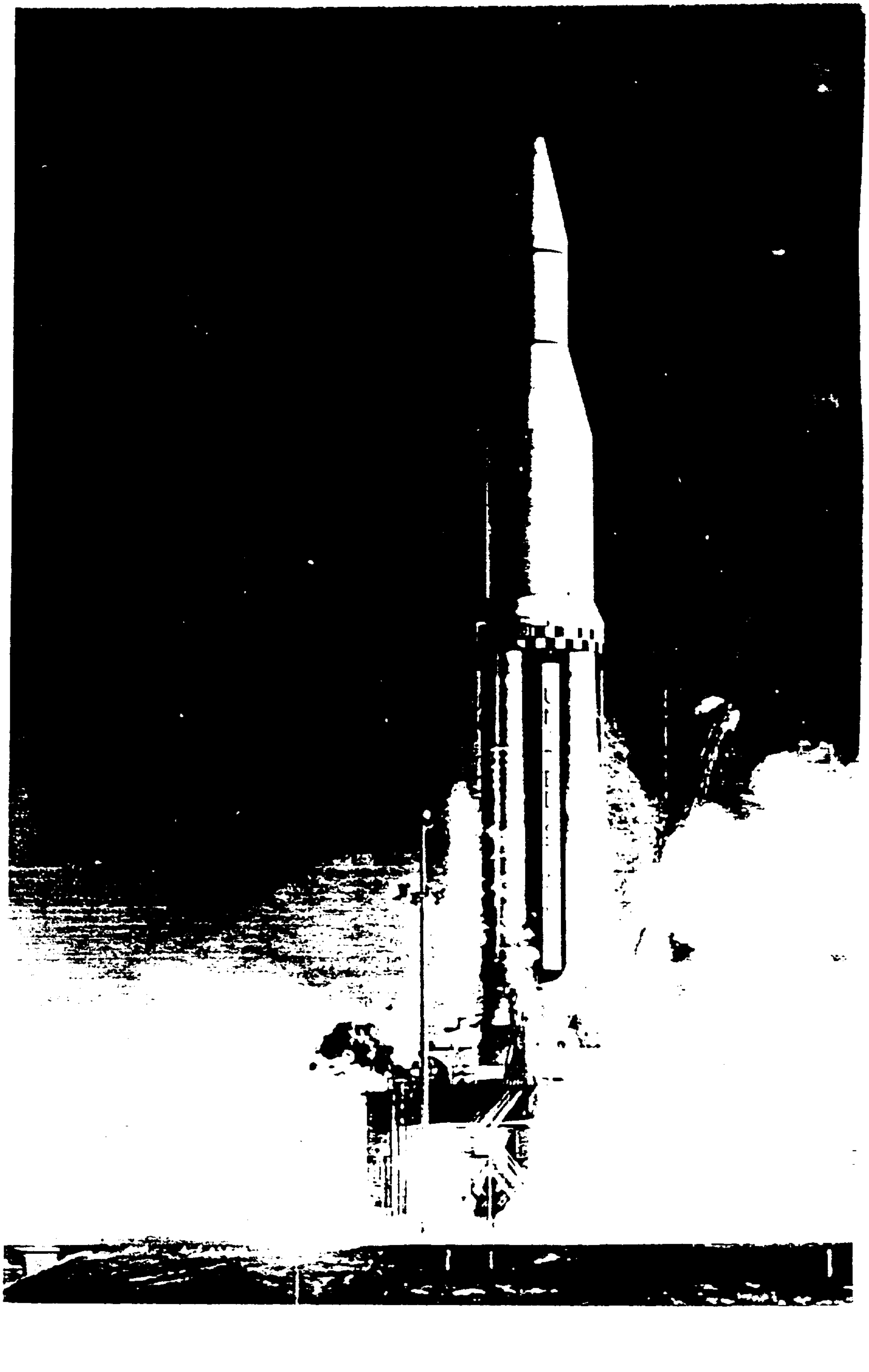
MAXIMUM DIAMETER: 21.6 ft., excluding fins

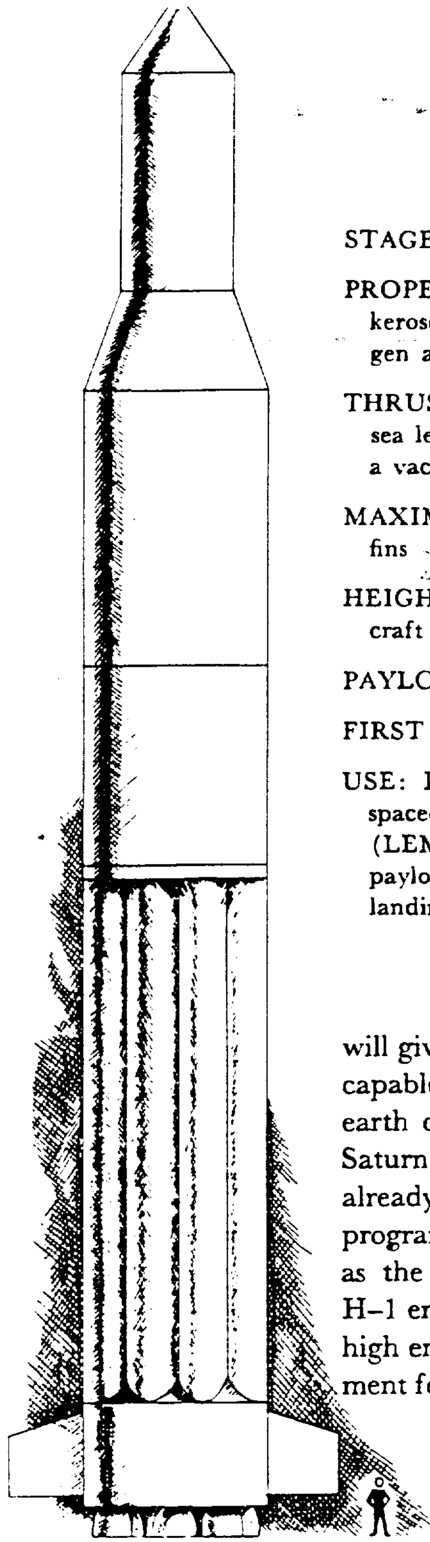
HEIGHT: 125 ft., less spacecraft

PAYLOAD: 20,000 lbs. in 300 n.m. orbit (15,000 lbs. without restart capability)

FIRST NASA LAUNCH: 1st stage, October 27, 1961; 2nd stage, 1963

USE: Launching into earth orbit of spacecraft being developed for the manned lunar landing program





(C–1B CONFIGURATION)

STAGES: 2

PROPELLANTS: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd stage, liquid oxygen and hydrogen (LOX/LH)

THRUST: 1st stage (S–I), 1,500,000 lbs. at sea level; 2nd stage (S–IVB), 200,000 lbs. in a vacuum

MAXIMUM DIAMETER: 21.6 ft., excluding fins

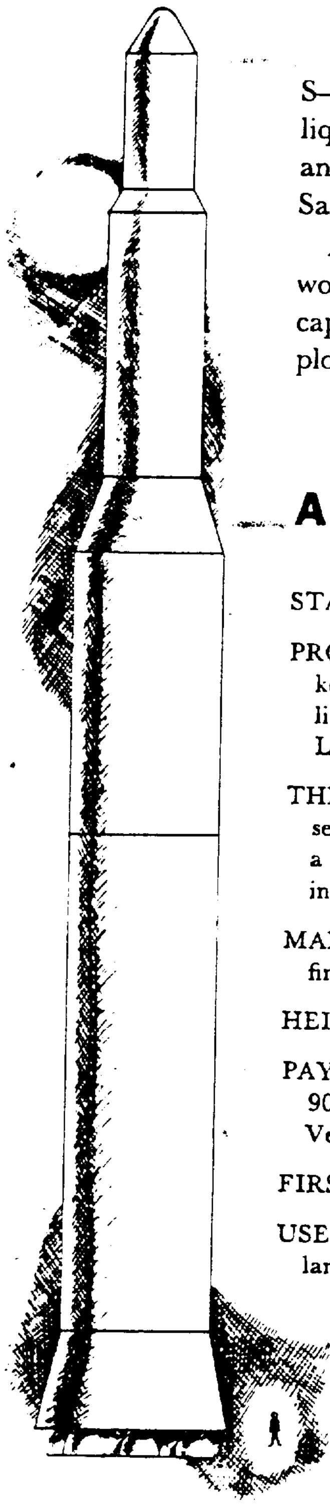
HEIGHT: Approximately 150 ft., less spacecraft

PAYLOAD: 32,000 lbs. in 100 n.m. orbit

FIRST NASA LAUNCH: 1965

USE: Launching into earth orbit of the Apollo spacecraft with its Lunar Excursion Module (LEM), as well as the launching of unmanned payloads in support of the manned lunar landing program

THE Saturn C–1B will give the United States a launch vehicle capable of placing a heavier payload into earth orbit than will be possible with the Saturn C–1. The C–1B will utilize stages already being developed for other vehicle programs. The first stage will be the same as the C–1, consisting of eight clustered H–1 engines. The second stage will be the high energy S–IVB already under development for use in the Advanced Saturn. The



S–IVB stage uses a single liquid-oxygen, liquid-hydrogen J–2 engine. The guidance system will be the same for all the Saturn vehicles.

A three-stage configuration under study would provide a four-ton payload escape capability for lunar and planetary exploration.

ADVANCED SATURN

STAGES: 3

PROPELLANTS: 1st stage, liquid oxygen and kerosene (LOX/RP); 2nd and 3rd stages, liquid oxygen and liquid hydrogen (LOX/LH)

THRUST: 1st stage (SI–C), 7,500,000 lbs. at sea level; 2nd stage (S–II), 1,000,000 lbs. in a vacuum; 3rd stage (S–IVB), 200,000 lbs. in a vacuum

MAXIMUM DIAMETER: 33 ft., excluding fins

HEIGHT: 280 ft., less spacecraft

PAYLOAD: 240,000 lbs. in 300 n.m. orbit; 90,000 lbs. escape; 70,000 lbs. to Mars or Venus

FIRST NASA LAUNCH: 1965

USE: Launching of circumlunar and lunar landing flights

THE dimensions of the page do not permit us to show the Advanced Saturn in its proper size in relation to the other launch vehicles in this booklet. The Advanced Saturn, also called the Saturn C–5, will be almost twice the height of the Saturn C–IB and will have a lift-off weight with payload of more than six million pounds. The first stage will be powered by five F–1 engines yielding a total of 7.5 million pounds of thrust. The second stage of the Advanced Saturn will be powered by five J–2 engines, each producing 200,000 pounds of thrust at altitude. The third stage will consist of a single J–2 engine. With this combination the Advanced Saturn will be capable of launching 120 tons into low earth orbit, 45 tons on lunar missions, or 35 tons on planetary missions.

The Advanced Saturn's tremendous lift-off force is produced by the F–1 engine, which has the same amount of thrust—1.5 million pounds—as all eight of the H–1 engines in the first stage of the Saturn C–1 and C–1B. The F–1 engine has already been static fired in full-duration tests.

The Advanced Saturn will be capable of sending the three-man Apollo spacecraft into orbit around the moon. The lunar landing will be accomplished by the two-man Lunar Excursion Module (LEM), which will be detached from the Apollo. After the landing mission is completed, the LEM will take off from the moon to make rendezvous with the Apollo in lunar orbit for the return journey to earth.

NOVA

THE largest vehicle in the current National Launch Vehicle Program is the Nova. The exact size has not yet been determined. Nova will have a single-launch weight-lifting capability of two to three times that of the Advanced Saturn. Inasmuch as the Advanced Saturn capability is approximately 45 tons to escape velocity or 120 tons to earth orbit, Nova is presently defined as being capable of launching 240 to 360 tons to earth orbit.

Potential missions utilizing this larger weight-lifting capability include:

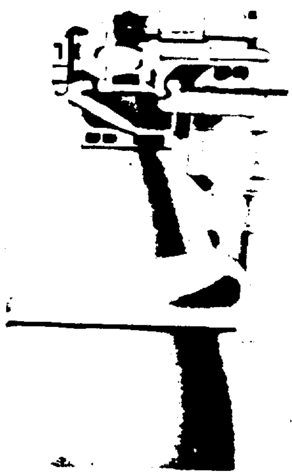
1. Delivery of passengers and cargo to earth orbit for assembly of spacecraft and escape stages for manned interplanetary exploration.
2. Delivery of passengers and cargo to the lunar surface for lunar missions.
3. Delivery of passengers and cargo to earth orbit for establishing and supplying large space stations.
4. Direct escape for interplanetary probes.

Nova will utilize two stages for orbital missions and three stages for escape missions. The vehicle will be about 300 feet in height, exclusive of its payload. The first and second stages will be about 50 feet in diameter. Both liquid and solid propellants are being studied for possible use in the first stage. The second and third stages will use high-energy liquid-oxygen, liquid-hydrogen propellants. Nova will be capable of accepting a nuclear-powered third stage when such a stage is developed and available.

During fiscal year 1963, NASA is carrying out intensive configuration studies to determine the size, propulsion system characteristics, and vehicle technology.

GPO : 1962 O—663324

H–1
188,000 LBS.
OXYGEN/KEROSENE



F–1
1,500,000 LBS.
OXYGEN/KEROSENE

M–1
1,200,000 LBS.
OXYGEN/HYDROGEN

J–2
200,000 LBS.
OXYGEN/HYDROGEN

A–3
15,000 LBS.
OXYGEN/HYDROGEN

ENGINES FOR MANNED FLIGHT